The potential of using an inverse modelling approach to predict soil PAWC for summer crops in Australia

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Abstract: Plant available water capacity (PAWC) is a critical soil functional property that influences crop productivity and water use efficiency by interacting with pre-season and in-season rainfall and other climatic variables. However, accurately measuring PAWC is expensive and time-consuming, making it difficult to obtain across large areas. An inverse modelling approach has previously been developed and tested for predicting soil PAWC from winter crop yields. The effectiveness of this approach for summer crops is still not clear, especially in summer rainfall domain regions.

In this study, the farming systems model APSIM was used to simulate three cropping systems, i.e., single sorghum, wheat and sorghum rotation, wheat and sorghum opportunity cropping at a summer rainfall site Emerald. These simulations were carried out with synthetic soil profiles with contrasting PAWC. The simulated results were used to develop negative exponential models that link the simulated sorghum yield to PAWC. The model was subsequently used inversely to predict PAWC from sorghum yield. To assess the potential prediction ability, independently sorghum yields were simulated with five real soil profiles, and then used to test the skill of the inverse model for prediction the PAWC of the five real soil profiles. Additionally, the Standardized Precipitation Index (SPI) was used to classify years into wet, neutral and dry categories. The prediction ability of inverse models was assessed for each year category to explore the possibility of developing generic models for PAWC predictions.

The inverse models explained over 74% of the variation in soil PAWC with RMSE less than 45 mm in single sorghum cropping system even when sorghum yield from a single year was used to predict PAWC. For the other two cropping systems, at least three to five consecutive years of sorghum yields were needed to get the similar prediction accuracy. Similar with the results of winter crops, with an average yield of five consecutive years or more, the inverse modelling approach can accurately predict soil PAWCs when they are less than 200 mm with a RMSE less than 25 mm.

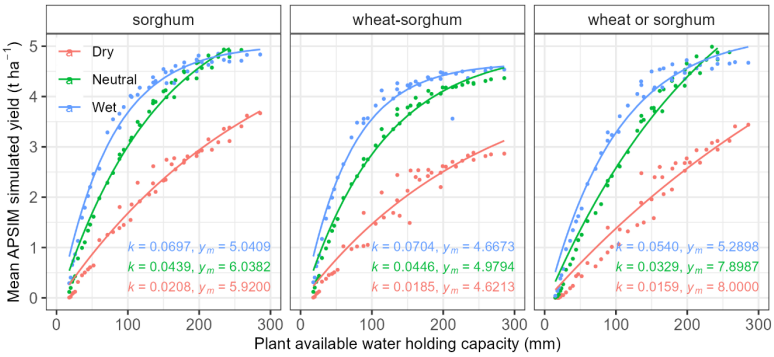

Figure 1. Impact of PAWC on the average of APSIM simulated sorghum yield for different rainfall categories in Emerlad. Solid lines are predictions from fitted negative exponential equations with parameters y_m – the maximum yield above which PAWC has no impact, and k – the initial slope of the curve

The relationship between sorghum yield and soil PAWC exhibited significant variation across three rainfall year types, i.e., dry, neutral, and wet years (Figure 1). Both parameters (y_m and k) in the inverse model changed with year types. The result highlights the challenge of establishing generic models for PAWC predictions applicable to individual years, although it may be possible to develop models for different year types. It also highlights the value of crop yield data from multiple consecutive years in the prediction of soil PAWC across sites.

Keywords: *APSIM, soil-plant interaction, negative exponential curve, SPI*